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BACKGROUND FACTORS AND SUCCESS IN COLLEGE PHYSICS.
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FACTORS RELATED TO ACADEMIC ACHIEVEMENT IN FIRST YEAR COLLEGE PHYSICS WERE IDENTIFIED. DATA WERE OBTAINED FROM THE RECORDS OF 923 STUDENTS WHO HAD COMPLETED THE FIRST SEMESTER OF A COLLEGE PHYSICS COURSE DURING A 5-YEAR PERIOD. MULTIPLE CORRELATIONS WERE USED TO RELATE STUDENT BACKGROUND VARIABLES TO ACHIEVEMENT IN COLLEGE PHYSICS. HIGH SCHOOL GRADE POINT AVERAGE AND CLASS RANK WERE THE MOST SIGNIFICANT PREDICTORS OF ACADEMIC ACHIEVEMENT. HIGH SCHOOL PHYSICS WAS ALSO A SIGNIFICANT PREDICTOR. BACKGROUND IN COLLEGE MATHEMATICS AND CHEMISTRY WERE SIGNIFICANTLY RELATED AT THE .05 LEVEL TO ACHIEVEMENT IN PHYSICS. HIGH SCHOOL MATHEMATICS PREPARATION WAS NOT A SIGNIFICANT PREDICTOR OF ACHIEVEMENT IN COLLEGE PHYSICS IN THIS STUDY. THIS ARTICLE IS PUBLISHED IN THE "JOURNAL OF RESEARCH IN SCIENCE TEACHING," VOLUME 4, ISSUE 2, 1966. (AG)

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The author has cast a new light on some old myths concerning predictors of success in college physics.

Background Factors and Success in College Physics

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A long standing question in the minds of science teachers involves the relative value of high school science courses for the student planning to take college courses in these areas. It has occasionally been suggested that high school background in the sciences is of no value to the college student in the same areas and that high school courses may actually be detrimental. On the other hand, many students and teachers seem strongly convinced that good backgrounds in mathematics represent the best preparation for college courses in areas such as chemistry and physics.

Background

A number of studies of the high school backgrounds of college students in chemistry and physics have been made over the past few years. One of the more extensive studies was reported by Adams and Garrett[1] in 1954 in which a study was made on 877 beginning physics students at Louisiana State University. They found that articulation between college physics and various types of high school work was poor but that high school records were better predictors of success in college physics than entrance examination scores. It was indicated, however, that at least high school physics does not hinder the student of college physics.

In another study by Foster[2] in which partial correlation techniques were used, a high partial correlation of 0.70 between success in general college physics and high school physics was noted. The partial correlation between success in general college physics and native intelligence was, however, higher at 0.77. By way of comparison, it is interesting to note that the partial correlation between college physics and high school mathematics was only 0.13. He concluded that high school physics was not a negligible factor in the success of college students of physics.

In still another study, Kruglak and Keller[3] attempted to find criteria which would be useful in selecting students for an accelerated class in sophomore college physics. Since the students were sophomores, one year of college work could be considered and it was found that the students' freshman honor point ratio was the best predictor of success in the first course in college physics. Other variables such as high school percentile rank in class and college entrance examination scores proved to be of little additional value provided the freshman honor point ratio was available.

Finger, Dillon, and Corbin[4] studied success in college physics for students classified as to their high school background in physics. They used three groups consisting of students with PSSC physics, students with conventional physics, and students with no high school physics. The results generally imply that no significant difference in performance in college physics exists among the three groups.

The Study

In a study of success in college physics at the State University of Iowa, the author used multiple correlation techniques to analyze the high school backgrounds of students who had completed the first se-

TABLE I
Background Variables Considered in the Study of Success in College Physics

Variable no.	Variable
1	College classification
2	Number of semesters of high school algebra
3	Number of semesters of high school geometry
4	Number of semesters of high school trigonometry
5	Number of years of high school chemistry
6	Number of years of high school physics
7	High school grade point average
8	High school rank in class
9	Number of semester hours of freshman college mathematics (if any)
10	Number of semester hours of calculus (if any)
11	Number of semester hours of college chemistry (if any)
12	Size of the high school graduating class

mester in college physics. The subpopulation selected for study consisted initially of 1235 students who had taken college physics over a five-year period ending in 1961. The course covered topics in mechanics, heat, and sound and was followed by a second semester of physics consisting of a study of electricity and magnetism, optics, and in some instances, topics in atomic and nuclear physics. There were no specific prerequisites for the course although an understanding of elementary algebra was assumed and trigonometry was used as needed throughout the course. Demonstrations were used regularly during lectures given three times each week and all students took a 2-hour conventional laboratory each week.

Students taking the course were preparing in various fields including medicine, pharmacy, chemistry, engineering, and teaching, as well as in physics. Most physics majors and some engineering majors, however, would have taken a different introductory course in physics which required more mathematical sophistication. Although the course was considered to be a freshman course, it was common for students in upper classifications to be registered. Hence, it was necessary to consider previous college work in science and mathematics for many students and these factors were included as additional independent variables in the study.

A large majority of the students under consideration graduated from Iowa high schools of widely varying sizes. The largest school had approximately 600 students in the graduating class while the smallest school had less than 20. The average size of the graduating class was 135. Over 80% of the students included in the study had taken high school physics but very few had been exposed to PSSC physics and no analysis of PSSC students could be attempted.

For the multivariate analysis used in this study, 923 of the 1235 students originally selected for study had complete data available. The criterion variable of success in college physics was based on a letter grade of A, B, C, D, or F obtained in the course at the end of the first semester. The twelve independent variables shown in Table I were considered in the first analysis.

Multivariate analysis with this number of variables and sample size would be difficult if not impossible without the use of a computer, and the IBM 7070 computer at the State University of Iowa was programed to make the analysis.

Table II shows the intercorrelation matrix for the variables listed in Table I. The variables are numbered as in Table I but the variable is relisted along the lefthand column to make comparisons easier. All correlations have been rounded off to two decimal places.

The criterion variable of grade in college physics is also listed in Table II as variable number 13.

Results

In the initial analysis using all twelve independent variables, a number of the variables appeared to be insignificant, but it is usually best to eliminate one variable at a

TABLE II
Intercorrelations between Variables Listed in Table I and the Criterion Variable of Grade in College Physics

Variable	Variable no.	1	2	3	4	5	6	7	8	9	10	11	12	13
College classification	1	1	−.17	−.11	−.10	.00	−.07	.06	.05	.13	.10	.53	−.05	.06
H.S. algebra	2		1	.20	.29	.16	.18	.19	.19	−.01	.13	−.05	.17	.10
H.S. geometry	3			1	.17	.05	.07	.11	.09	.04	.04	−.02	.05	.06
H.S. trig.	4				1	.19	.18	.15	.15	−.06	.08	−.06	.18	.14
H.S. chem.	5					1	.14	.17	.18	−.09	.01	.07	.16	.13
H.S. physics	6						1	.07	.06	−.03	.03	−.02	.00	.11
H.S. G.P.A.	7							1	.81	−.08	.05	.07	−.04	.44
H.S. rank	8								1	−.08	.03	.09	−.01	.37
College math.	9									1	.22	.18	−.05	−.08
College calc.	10										1	−.05	.05	.10
College chem.	11											1	−.01	.13
H.S. class size	12												1	.03
College physics (criterion)	13													1

TABLE III
b Values, b^* Values, and F tests of Significance for the Remaining Variables after Repeated Deletions of Insignificant Variables

Variable no.	Variable	b value	b^* value	F value
6	High school physics	0.179	0.067	5.161
7	High school grade point average	0.069	0.406	188.102
9	Freshman college mathematics	−0.027	−0.100	10.564
10	College calculus	0.057	0.112	13.963
11	College chemistry	0.021	0.125	17.323

$a = -0.225$; $F_{0.05} = 3.85$; $N = 923$; multiple correlation coefficient = 0.47.

time since the partial correlation value of all remaining variables will change slightly with each variable deleted. The computer can be programed to delete variables one at a time until only variables with a predetermined significance level remain. For this analysis, the F test of significance was used with 0.05 as the level of significance. A complete discussion of multiple correlation procedures and tests of significance can be found in standard statistics texts.[6,7]

Table III indicates the results of the analysis after deletion of variables which proved to be insignificant. The b values in the table are coefficients which could be used in a prediction equation relating the remaining independent variables and the student's probable success in physics. The constant a

would also appear in the prediction equation. The b^* values, on the other hand, are normalized b values and give a measure of the relative importance of each of the remaining independent variables. The multiple correlation coefficient is also shown in the table and is sufficiently high to indicate that a prediction equation based on the variables shown would yield reasonably accurate results.

Discussion and Conclusions

As indicated in Table III, only five of the original twelve variables remained as significant predictors of success in college physics. The high school grade point average is obviously the best predictor of success in college physics and this is not unexpected. Grade point averages would generally be highly correlated with intelligence, and undoubtedly either factor would be a good predictor of success in college physics. One might immediately question why high school rank in class did not remain as a significant variable since it would normally be highly correlated to both high school grade point average and intelligence. The high correlation does exist in this study with a simple correlation of 0.81 between high school grade point average and high school rank in class. However, the multiple correlation technique searches for the best possible combination of prediction variables and two highly correlated variables cannot both aid in the prediction. In fact, if the variables are perfectly correlated, the second variable can add nothing whatever to the prediction equation. As a check on this statement, the data was rerun with the variable of high school grade point average deleted. High school rank in class then became a high significant variable occupying approximately the same place as high school grade point average in Table III.

The variable of high school physics, however, is the most interesting. Although it is obviously the least important of the five remaining variables as a predictor of success in physics, it does in fact remain as a significant predictor. Remembering that multivariate analysis effectively holds all other variables constant in the process of obtaining the figures shown in Table III, it would seem logical to conclude that a course in high school physics is an asset to the student taking the introductory course in college physics. Raw score data showed that students with high school physics had a grade point average of 2.14 in college physics while those without high school physics averaged 1.82. The numerical system used to obtain these figures is based on representing a letter grade of A as 4.0, B as 3.0, C as 2.0, D as 1.0, and F as 0.0.

Even more interesting is the fact that variables related to background in high school mathematics were found to be insignificant as predictors of success in the first course in college physics. Since this is at variance to the thinking of many people, a number of checks were made by rerunning the multivariate analysis using various combinations of high school mathematics variables and also by using a single variable representing the sum of semesters of high school mathematics. In all cases, the results were negative with these variables being deleted as insignificant. It is important to note that the students studied had a full range of backgrounds in mathematics from as little as one semester of algebra to a full four years of mathematics in high school. The reason for the lack of importance of high school mathematics background may involve the fact that most tests in the first course in college physics require careful analysis of a written problem and the setting up of mathematical equations rather than manipulative skills with equations. The student who had completed four years of high school mathematics may have become adept at solving equations but may still have great difficulty arriving at an equation to soive when faced with a written problem in physics. In addition, since the college course in physics was noncalculus-oriented, the level of mathematical sophistication was very low and well within the range of high school courses.

The fact that variables 9, 10, and 11 related to college background in science and mathematics remain as significant variables for prediction of success in college physics may not be surprising since students with many hours in these areas are becoming science-oriented and are probably majoring in science or mathematics. However, the negative sign with the b and b^* coefficients of variable 9 is most confusing. It implies that a student with many hours in freshman college mathematics is likely to do poorer in college physics. Although not the purpose of this research, the study of this unexpected result consumed a great amount of time. After extensive rechecking of the original data and a number of calculation cross checks, it was clear that the negative sign was not in error. In fact, the simple correlation between the number of hours of freshman college mathematics and success in college physics was -0.08. The simple correlation is negative and although it seems small, the variable does remain as a significant predictor in the multivariate analysis.

It seems unlikely that the negative sign could represent a cause and effect relationship. Apparently students who delayed taking physics and took many hours in freshman mathematics were deficient in some other respect or of lesser ability. Perhaps the better students were advised or elected to go directly into calculus. Such students would, of course, have had no hours in freshman mathematics although they may have done very well in college physics.

Summary

In summary, the results of this study clearly indicate that for the students under consideration, high school physics was an asset in the first course in college physics. In addition, high school physics has predictive value in determining a student's probable success in college physics although the factor of native intelligence as measured by the high school grade point average is of much more value. On the other hand, high school background in mathematics appears to have no predictive value in determining success in college physics and it must be concluded that the student with extensive background in high school mathematics has no material advantage in this course in college physics because of the mathematics background.

As a final point, it should be made clear that recent work in PSSC physics in high school would have had no effect on the results of this study. A check of students in the most recent year of study showed that less than one percent had been exposed to PSSC physics. This was apparently due to the initially slow adoption of the course in area high schools. In addition, many students included in the study would have completed high school work before PSSC physics was introduced.

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